

caused by the northerly winds that prevailed during the above-mentioned period, and which drove the water off the coast. Just now the lowering of the atmospheric pressure, that had been as high as 778 millimetres, gave a prevalence to southerly winds, and the sea reached again its former level.

L. LUIGGI,

Resident Engineer at the Pier Works, Genoa, Italy
February 28

A Strange Phenomenon

RELATIVE to the letter of Mr. James Moir, under the above title, which appeared recently in NATURE, I beg to observe that in the Highlands of Perthshire, some forty years ago, two men found themselves enveloped in flames, somewhat in the same style as Mr. Moir was on February 18 last. One Mr. John Stewart, who, for many years, drove the Mail gig between Dunkeld and Aberfeldy, told me that on a certain dark night, he and another man, climbing a rocky, heathery height in Rannock, were all at once set on flames by some mysterious fire, which appeared to proceed from the heather, which they were traversing, and the more they tried to rub the flames off the more tenaciously they seemed to adhere, and the more the fire increased in brightness and magnitude. Moreover, the long heather agitated by their feet, emitted streams of burning vapour, and for the space of a few minutes they were in the greatest consternation. They believed that they barely escaped a living cremation. Of course their liberal share of native superstition, along with the weird gloom of the night in the weird wilderness remote from human habitation, rendered their position the more alarming. Mr. Stewart did not mention whether the weather was stormy or not; but without doubt the object of their fear was St. Elmo's Fire. The ignis fatuus has been frequently seen in these Highland districts hovering over marshes, rivers, and churchyards, which was believed by the superstitious to be the ghosts of the dead. When the ignis fatuus was seen flickering over the graveyard, it was a sign—with them—that some one was to be buried there soon, and when seen floating over a river, it was a sign that some one was to be drowned there that night or soon after, the floating, wandering lights being their ghosts. Drainage, in this respect, has effected many changes.

DONALD CAMERON

45, Calder Street, Govanhill, Glasgow, March 6

MR. JAMES MOIR, in last week's NATURE (p. 410), mentions a probable peculiar manifestation of St. Elmo's Fire, and asks if any one can give instances of a similar occurrence. About twenty years ago I was returning, during the evening, to my house from Great Yarmouth, a distance of three miles, and took the road of the Denes, intending to cross by the lower ferry. Before reaching it a dark cloud coming from the south-east, off the sea, suddenly surprised me, and drenched me with rain. I jumped into the boat, and when the boatman had pushed off, I remarked that every drop of rain hanging from my hair, beard, and clothes was luminous with white light, well seen, as it was very dark at the time. I found the same appearance had been observed by several pilots exposed to the same shower. I always attributed the occurrence to a species of St. Elmo's fire. It was mentioned at the time by a friend of mine at a scientific meeting in London, and thought curious.

W. H. C. B.

Cheltenham, March 7

Parhelia

OF the parhelia of January 27 seen by M. Albert Riggerbach (NATURE, vol. xxv. p. 364) I was a spectator, and noted my observations at once. I was walking near Pavia when I observed the phenomenon about 3.45. A mock sun (one only) was in the same altitude with the sun on the horizon; M. Riggerbach's *faint cirrus* obviously corresponds to the *filamenti nebbiosi* in my note; they were as I well remember, with the mock sun in the eastern part of the sky, while in the opposite region some blackish *cumuli* approached slowly.

FRANCIS PORRO

Pavia, Lombardy, February 27

Red Flints in the Chalk

ARE red flints common in the Chalk? A portion of our College farm lies on a gentle slope on the Upper Chalk, which rises westward from the banks of the Hampshire Avon. On the

higher parts of this slope black flints are excessively abundant, so much so that after sheep have been folded on the land, the fields present the appearance of a newly macadamised road, and the flints are picked up and put into heaps until an opportunity offers to use them for road-metal; in the course of a year they "grow" again as thickly as before. But one field on a ridge near the foot of the slope is remarkable for the number of red flints it contains; on the dusty soil they look just like bits of broken earthenware, and might at first fail to attract attention. Their size is much less than the average size of the black flints; some are rounded and some angular, others almost flake like. As to the frequency of their occurrence, I found I was able to pick up at least one at every step I took.

W. FREAM

College of Agriculture, near Downton, Salisbury,
February 28

THE SALMON DISEASE¹

FOR some years an epidemic disease, followed by a very large number of deaths, has been observed to prevail among the salmon of certain Scottish and British rivers, from the Tay, on the north, as far as the Conway on the south.

The first obvious symptom of the malady is the appearance of one or more whitish patches upon the skin of parts of the body which are not covered with scales, such as the top and sides of the head, the adipose fin, and the soft skin at the bases of the other fins.

Such a patch, when it first attracts attention, may be as big as a sixpence. It is nearly circular, with a well-defined margin and a somewhat raised softer centre, from which faint ridges radiate towards the circumference. It is important to observe that a single small patch of this kind may be seen on the skin of a fish which, in all other respects, is perfectly healthy, and when there is no indication that the skin has ever been bruised or abraded in the place occupied by the patch. The patch, once formed, rapidly increases in size, and becomes confluent with any other patches which may have appeared in its neighbourhood. The marginal area, as it extends over the adjacent healthy skin, retains its character; but the central part undergoes an important change. It takes on the consistency of wet paper, and can be lifted up in soft flakes, as if it were a slough, from the surface of the derma or true skin, which it covers. In fact, it is obvious that this papyraceous substance has taken the place of the epidermis, so that the sensitive and vascular true skin is deprived of its natural protection. As the patch spreads, the true skin beneath the central papyraceous slough ulcerates and an open bleeding sore is formed, which may extend down to the bone, while it passes outwards into burrowing sinuses.

When the disease has reached this stage it obviously causes great irritation. The fish dash about and rub themselves against stones, and thus in all probability aggravate the evils under which they suffer. One vast open sore may cover the top of the head from the snout to the nape, and may extend over the gill covers. The edges of the fins become ragged; and, sometimes, the skin which invests them is so completely frayed away that the fin-rays stand out separately.

Although the affection of the skin appears, usually, if not invariably, to commence in the scaleless parts of the body, it does not stop there, but gradually spreads over the whole of the back and sides of the fish, though I have not yet seen a specimen in which it covered the whole ventral surface. The disease extends into the mouth, especially affecting the delicate valvular membrane attached to the inner sides of the upper and the lower jaws. It is said to attack the gills, but there has been no sign of it on these organs in any fish which I have had the opportunity of examining.

Fish which succumb to the disease become weak and

¹ A Contribution to the Pathology of the Epidemic known as the "Salmon Disease." Paper read at the Royal Society, March 2, by Prof. T. H. Huxley, LL.D., F.R.S.

sluggish, seeking the shallows near the banks of the river, where they finally die.

The flesh of a salmon affected by this disease presents no difference in texture or colour from that of a healthy fish; and those who have made the experiment declare that the flavour is just as good in the former case as in the latter. So far as my observations have gone the viscera may be perfectly healthy in the most extensively diseased fish; and there is no abnormal appearance in the blood.

It is known that a disease similar to that described is occasionally prevalent among salmon in North America and in Siberia; and I do not see any ground for the supposition that it is a novelty in British rivers. But public attention was first directed to it in consequence of its ravages in the Solway district a few years ago; and, in 1878, a Commission was appointed to inquire into the subject.

The evidence taken by the Commissioners leaves no room for doubt that the malady is to be assigned to the large and constantly increasing class of diseases which are caused by parasitic organisms. It is a contagious and infectious disease of the same order as ringworm in the human subject, mescaline among silkworms, or the potato disease among plants; and, like them, is the work of a minute fungus. In fact, the *Saprolegnia* which is the cause of the salmon disease is an organism in all respects very closely allied to the *Peronospora*, which is the cause of the potato disease.

It is a very curious circumstance, however, that while the *Peronospora* are always parasites—that is to say, depend altogether upon living plants for their support—the *Saprolegnia* are essentially saprophytes; that is to say, they ordinarily derive their nourishment from dead animal and vegetable matters, and are only occasionally parasites upon living organisms. In this respect they resemble the *Bacteria*, if the results of recent researches, which tend to show that pathogenic bacteria are mere modifications of saprogenic forms, are to be accepted.

As I have said, I do not think that the evidence laid before the Commission of 1878 can leave any doubt as to the causation of the salmon disease on the minds of those who are acquainted with the history of the analogous diseases in other animals and in plants. Nevertheless, this evidence, valuable as it is, suggests more questions than it answers, and in November, 1881, hearing that the disease had broken out in the Conway, I addressed myself to the attempt to answer some of these.

It was already known that when the papyraceous slough-like substance which coats the skin of a diseased salmon is subjected to microscopic examination, it is found to be a *mycelium*, or fungus-turf, composed of a felt-work of fine tubular filaments or *hyphæ*, many of which are terminated by elongated oval enlargements, or *zoosporangia*. Within these the protoplasm breaks up into numerous spheroidal particles, each less than 1-2000th of an inch in diameter. These, the *zoospores*, are set free through an opening formed at the apex of the *zoosporangium*, and become actively or passively dispersed through the surrounding water. Herein lies the source of the contagiousness or infectiousness of the disease. For any one of these zoospores, reaching a part of the healthy skin of the same or of another salmon, germinates and soon gives rise to a mycelium similar to that from which it started.

But I could find no satisfactory information as to the manner in which the fungus enters the skin, how far it penetrates, the exact nature of the mischief which it does, or what ultimately becomes of it; nor was the identity of the pathogenic *Saprolegnia* of the salmon with that of any known form of saprogenic *Saprolegnia* demonstrated. It appeared to me, however, to be useless to attempt to deal with the disease until some of these important elements of the question were determined.

To this end, in the first place, I made a careful examination of the minute structure of both the healthy and diseased skin, properly hardened and cut into thin sections; and, in the second place, I tried some experiments on the transplantation of the *Saprolegnia* of the living salmon to dead animal bodies. Perhaps it will conduce to intelligibility if I narrate the results of the latter observations first.

The body of a recently killed common house-fly was gently rubbed two or three times over the surface of a patch of the diseased skin of a salmon, and was then placed in a vessel of water, on the surface of which it floated, in consequence of the large quantity of air which a fly's body contains. In the course of forty-eight hours, or thereabouts, innumerable white cottony filaments made their appearance, set close side by side, and radiated from the body of the fly in all directions. As these filaments had approximately the same length, the fly's body thus became inclosed in a thick white spheroidal shroud, having a diameter of as much as half an inch. As the filaments are specifically heavier than water, they gradually overcome the buoyancy of the air contained in the tracheæ of the fly, and the whole mass sinks to the bottom of the vessel. The filaments are very short when they are first discernible, and usually make their appearance where the integument of the fly is softest, as between the head and thorax, upon the proboscis, and between the rings of the abdomen. These filaments, in their size, their structure, and the manner in which they give rise to zoosporangia and zoospores are precisely similar to the hyphæ of the salmon fungus; and the characters of the one, as of the other, prove that the fungus is a *Saprolegnia* and not an *Achlya*. Moreover, it is easy to obtain evidence that the body of the fly has become infected by spores swept off by its surface when it was rubbed over the diseased salmon skin. These spores have in fact germinated, and their hyphæ have perforated the cuticle of the fly, notwithstanding its comparative density, and have then ramified outwards and inwards, growing at the expense of the nourishment supplied by the tissues of the fly.

This experiment, which has been repeated with all needful checks, proves that the pathogenic *Saprolegnia* of the living salmon may become an ordinary saprogenic *Saprolegnia*; and, *per contra*, that the latter may give rise to the former; and they lead to the important practical conclusion that the cause of salmon disease may exist in all waters in which dead insects, infested with *Saprolegnia*, are met with; that is to say, probably in all the fresh waters of these islands, at one time or another.

On the other hand, *Saprolegnia* has never been observed on decaying bodies in salt water, and there is every reason to believe that, as a saprophyte, it is confined to fresh waters.¹

Thus it becomes, to say the least, a highly probable conclusion that we must look for the origin of the disease to the *Saprolegnia* which infest dead organic bodies in our fresh waters. Neither pollution, drought, nor overstocking will produce the disease if the *Saprolegnia* is absent. The most these conditions can do is to favour the development or the diffusion of the *materies morbi* where the *Saprolegnia* already exists.

Having infected dead flies with the salmon *Saprolegnia*, once from Conway and once from Tweed fish, I was enabled to propagate it from these flies to other flies, and, in this manner, to set up a sort of garden of *Saprolegnia*. And having got thus far, I fancied it would be an easy task to determine the exact species of the *Saprolegnia* with which I was dealing, from the abundant data furnished by the works of Pringsheim, De Barry, and others,

¹ So far as I know there is only one case on record of the appearance of a fungus on a fish in salt water, and in this case it is not certain that the fungus was a *Saprolegnia*.

who have so fully studied these plants when cultivated on the same materials. For this purpose, it was necessary to obtain the oosporangia; and in ordinary course, these should have made their appearance on my *Saprolegnia* in five or six days. Unfortunately, in the course of cultivation continued over two months, nothing of the kind has taken place. Zoosporangia have abounded in the ordinary form and also in that known as "dictyosporangia," but, in no instance, have any oosporangia appeared. After a few days of vigorous growth, the zoosporangia become scanty, and the fungus takes on a torulose form, segments of the hyphæ becoming swollen and then detached as independent "gemmae," which may germinate. Sometimes the gemmæ are spheroidal and terminal, and closely simulate oosporangia.

Although, therefore, I have very little doubt that the *Saprolegnia* of the salmon is one of the forms of the "*S. ferax* group" of Pringsheim and De Bary, I have, at present, no proof of the fact.

Another very curious and unexpected peculiarity of the salmon *Saprolegnia*, both on the fish and when transmitted to flies, so far as my observations have hitherto gone, is that locomotive ciliated zoospores do not occur. I once saw one which exhibited a very slight motion for a few minutes after it left the zoosporangium; but although thousands must have passed under my notice, with the exception to which I have referred, they have always been perfectly quiescent and not unfrequently in different stages of germination. Whether the season of the year, or the conditions under which my saprolegnised flies were placed, have anything to do with the non-appearance of oosporangia and of locomotive zoospores in them I cannot say. But it is certain that the *Saprolegnia ferax* which commonly appears upon dead flies and other insects normally develops both oosporangia and locomotive zoospores in abundance.

From such notices by other observers as I can gather, oosporangia appear to be of very rare occurrence in the *Saprolegnia* of the salmon itself. Mr. Stirling mentions that he has met with them only four times. With respect to locomotive zoospores, I can find no positive evidence that they have been regularly, or even frequently, observed in the salmon *Saprolegnia*. But these points require careful investigation on freshly taken diseased fish.

Whether the zoospores are actively locomotive or not, they are quite free when they emerge from the zoosporangia; and, from their extreme minuteness, they must be readily carried away and diffused through the surrounding water. Hence, a salmon entering a stream inhabited by the *Saprolegnia* will be exposed to the chance of coming into contact with *Saprolegnia* spores; and the probability of infection, other things being alike, will be in proportion to the quantity of the growing *Saprolegnia*, and the vigour with which the process of spore-formation is carried on. At a very moderate estimate, a single fly may bear 1,000 fruiting hyphæ; and if each sporangium contains twenty zoospores, and runs through the whole course of its development in twelve hours, the result will be the production of 40,000 zoospores in a day, which is more than enough to furnish one zoospore to the cubic inch of twenty cubic feet of water. Even if we halve this rate of production, it is easy to see that the *Saprolegnia* on a single fly might furnish spores enough to render such a small shallow stream as salmon often ascend for spawning purposes, dangerous for several days. But a large fully diseased salmon may have as much as two square feet of its skin thickly covered with *Saprolegnia*. If we allow only 1,000 fruiting hyphæ for every square inch, we shall have 288,000 for the whole surface, which, at the same rate as before, gives over 10,000,000 spores for a day's production, or enough to provide a spore to every cubic foot of a mass of water 100 feet wide and five feet deep and four miles long. Forty such diseased salmon might furnish one spore to the gallon

for all the water of the Thames (380,000,000 gallons per diem) which flows over Teddington Weir. But two thousand diseased salmon have been taken out of a single comparatively insignificant river in the course of a season.

It will be understood that the above numerical estimate of the productivity of *Saprolegnia*, has been adopted merely for the sake of illustration; that I do not intend to suggest that the zoospores are evenly distributed through the water into which they are discharged by the zoosporangia; and that allowance must be made for the very short life of those zoospores which do not speedily reach an appropriate nidus. Nevertheless, the conclusion remains arithmetically certain that every diseased salmon adds immensely to the chances of infection of those which are not diseased; and thus, the policy of extirpating every diseased fish as soon as possible, has ample justification. But, in practice, the attempt to stamp out the disease in this fashion would be so costly that it may be a question whether it is not better to put up with the loss caused by the malady.

There are many practical difficulties in the way of directly observing the manner in which the zoospores effect their entrance into the skin of the fish; but, on comparing the structure of the healthy integument with that of the diseased patches, the manner of the operation can readily be divined. The skin of the head of a salmon, for example, presents a thin superficial cellular epidermis covering the deep fibrous and vascular derma. The epidermic cells are distinguishable, as in fishes in general, into a deep, a middle, and a superficial layer. In the first, the cells are vertically elongated, in the second more rounded and polygonal, in the third flattened. Many of the cells of the middle layer are of the nature of "mucous cells." They enlarge and become filled with a mucous secretion; and, rising to the surface, burst and discharge their contents, which give rise to the mucous fluid with which the fish's body is covered. The openings of these "mucous cells" remain patent for some time and are to be seen in thin vertical sections. The hyphæ of the spores which attach themselves to the fish may enter by these openings, but even if they do not, the flattened superficial cells certainly offer no greater resistance than does the tough cuticle of a fly. However this may be, sections of young patches of diseased skin show that the hyphæ of the fungus not only traverse the epidermis, but bore through the superficial layer of the derma for a distance, in some cases, of as much as one-tenth of an inch. Each hypha thus comes to have a stem-part, which lies in the epidermis, and a root-part, which lies in the derma. Each of these elongates and branches out. The free ends of the stem-hyphæ rise above the surface of the epidermis and become converted into zoosporangia, more or fewer of the spores of which attach themselves to the surrounding epidermis and repeat the process of penetration. Thus the epidermis and the derma become traversed by numerous hyphæ set close side by side. But, at the same time, these hyphæ send off lateral branches which spread radially, forcing asunder the middle and deeper layers of the epidermic cells, and giving rise to the radiating ridges which are visible to the naked eye in the peripheral part of the patch. The force of the growth of the hyphæ which traverse the epidermis, is made obvious by the curious manner in which, when the central tract of a patch is teased out, the distorted epidermis cells are seen adhering to it as if they were spitted upon it.

In the derma, the root-hyphæ branch out, pierce the bundles of connective tissue, and usually end in curiously distorted extremities.

The effect of the growth of the stem-hyphæ is to destroy the epidermis altogether. Its place is taken by a thick, felted, mycelium, which entangles the minute particles of sand which are suspended in the water, and thus no doubt

constitutes a very irritating application to the sensitive surface of the true skin.

In the true skin, the tracks of the root-hyphæ are not accompanied by any obvious signs of inflammation, but the hyphæ are so close set, that they cannot fail to interfere with the nutrition of the part, and thus bring about necrosis and sloughing. Such sloughing in fact gradually takes place, small vessels give way and bleed, and the burrowing sore, which is characteristic of the advanced stages of the disease is produced.

The skin of the head may thus be eaten away down to the bone and gristle of the skull, but I have not observed the fungus to enter these. On the scaly part of the skin, the fungus burrows in the superficial and in the deep layer of the pouches of the scales, but I have not observed the scales themselves to be perforated.

When I found that the fungus penetrated the true skin, and thus gained access to the lymphatic spaces and blood-vessels, it became a matter of great interest to ascertain whether the hyphæ might not break up into turuloid segments (as in the case of the *Empusa muscæ*), and thus give rise to general septic poisoning, or fungoid metastasis. However, I have never been able to find any indication of the occurrence of such a process.

But a very important practical question arises out of the discovery that the fungus penetrates into the derma. There is much reason to believe, that if a diseased salmon returns to salt water, all the fungus which is reached by the saline fluid is killed, and the destroyed epidermis is repaired. But the sea water has no access to the hyphæ which have burrowed into the true skin; and hence it must be admitted to be possible, that, in a salmon which has become to all appearance healed in the sea, and which looks perfectly healthy when it ascends a river, the remains of the fungus in the derma may break out from within, and the fish become diseased without any fresh infection. It has not infrequently been observed, that salmon in their upward course became diseased at a surprisingly short distance from the sea, and it is possible that the explanation of the fact is to be sought in the revival of dormant *Saprolegnia*, rather than in new infection. It is to be hoped, that experiments, now being carried on at Berwick, will throw some light on this point, as well as upon the asserted efficacy of sea water in destroying the fungus which it reaches.

These are the chief results of this season's observations on the salmon disease. Incomplete as they are, they appear to me to justify the following conclusions:—

1. That the *Saprolegnia* attacks the healthy living salmon exactly in the same way as it attacks the dead insect, and that it is the sole cause of the disease, whatever circumstances may, in a secondary manner, assist its operations.

2. That death may result without any other organ than the skin being attacked, and that, under these circumstances, it is the consequence partly of the exhaustion of nervous energy by the incessant irritation of the felt mycelium with its charge of fine sand, and partly of the drain of nutriment appropriated by the fungus.

3. That the penetration of the hyphæ of the *Saprolegnia* into the derma renders it at least possible that the disease may break out in a fresh-run salmon without re-infection.

4. That the cause of the disease, the *Saprolegnia*, may flourish in any fresh water, in the absence of salmon, as a saprophyte upon dead insects and other animals.

5. That the chances of infection for a healthy fish entering a river, are prodigiously increased by the existence of diseased fish in that river, inasmuch as the bulk of *Saprolegnia* on a few diseased fish vastly exceeds that which would exist without them.

6. That as in the case of the potato disease, the careful extirpation of every diseased individual is the treatment theoretically indicated; though, in practice, it may not be worth while to adopt the treatment.

ON THE CONSERVATION OF SOLAR ENERGY¹

THE question of the maintenance of Solar Energy is one that has been looked upon with deep interest by astronomers and physicists from the time of La Place downwards.

The amount of heat radiated from the sun has been approximately computed by the aid of the pyrheliometer of Pouillet and by the actinometers of Herschel and others at 18,000,000 of heat units from every square foot of its surface per hour, or, put popularly, as equal to the heat that would be produced by the perfect combustion every thirty-six hours of a mass of coal of specific gravity = 1.5 as great as that of our earth.

If the sun were surrounded by a solid sphere of a radius equal to the mean distance of the sun from the earth (95,000,000 of miles), the whole of this prodigious amount of heat would be intercepted; but considering that the earth's apparent diameter as seen from the sun is only seventeen seconds, the earth can intercept only the 2,250-millionth part. Assuming that the other planetary bodies swell the amount of intercepted heat by ten times this amount, there remains the important fact that $\frac{2250}{18000000000}$ of the solar energy is radiated into space, and apparently lost to the solar system, and only $\frac{2250}{18000000000}$ utilised.

Notwithstanding this enormous loss of heat, solar temperature has not diminished sensibly for centuries, if we neglect the periodic changes, apparently connected with the appearance of sun-spots that have been observed by Lockyer and others, and the question forces itself upon us how this great loss can be sustained without producing an observable diminution of solar temperature even within a human lifetime.

Amongst the ingenious hypotheses intended to account for a continuance of solar heat is that of shrinkage, or gradual reduction of the sun's volume suggested by Helmholtz. It may, however, be urged against this theory that the heat so produced would be liberated throughout its mass, and would have to be brought to the surface by conduction, aided perhaps by convection; but we know of no material of sufficient conductivity to transmit anything approaching the amount of heat lost by radiation.

Chemical action between the constituent parts of the sun has also been suggested; but here again we are met by the difficulty that the products of such combination would ere this have accumulated on the surface, and would have formed a barrier against further action.

These difficulties have led Sir Wm. Thomson, following up Mayer's speculation, to the suggestion that the cause of the maintenance of solar temperature might be found in the circumstance of meteorolites falling upon the sun from great distances in space, or with an acquired velocity due to such fall, and he shows that each pound of matter so imported would represent a large number of heat units depending upon the original distance. Yet the aggregate of material that would thus have to be incorporated with the sun would tend to disturb the planetary equilibrium, and must ere this have shortened our year to an extent, exceeding that resulting from astronomical records and observation. In fact, Sir William Thomson soon abandoned the meteoric hypothesis for that of simple transfer of heat from the interior of a liquid sun to the surface by means of convection currents, which latter hypothesis appears at the present time to be supported by Prof. Stokes and other leading physicists of the day.

But if either of these hypotheses could be proved we should only have the satisfaction of knowing that the solar waste of energy by dissipation into space was not dependent entirely upon loss of its sensible heat, but that

¹ Paper read at the Royal Society, March 2, by C. William Siemens, D.C.L., LL.D., F.R.S., Mem. Inst. C.E.